DOCKETED	
Docket Number:	19-ERDD-01
Project Title:	Research Idea Exchange
TN #:	240742
Document Title:	CTO Rebound Technologies Comments - Energy Efficiency and Demand Response
Description:	N/A
Filer:	System
Organization:	CTO Rebound Technologies
Submitter Role:	Public
Submission Date:	11/30/2021 4:02:52 PM
Docketed Date:	11/30/2021

Comment Received From: CTO Rebound Technologies
Submitted On: 11/30/2021
Docket Number: 19-ERDD-01

Energy Efficiency and Demand Response

Additional submitted attachment is included below.

°ReboundTechnologies

Response to 19-ERDD-01

IcePoint, Freeze Point Suppression, and the value of embedded energy storage for long duration demand response

November 30, 2021

Introduction to IcePoint

Rebound designed IcePoint to integrate energy storage into industrial refrigeration at the scale, efficiency, and cost required to support demand response for a fully renewable grid. IcePoint is a refrigeration cycle with embedded thermal energy storage and inherent dehumidification. The energy storage provided by IcePoint is the lowest cost option for demand response and scalable far beyond traditional demand response capacities in terms of both power and energy.

IcePoint delivers exceptional value to its customers in the form of agile freezing and unprecedented dehumidification which both increase the throughput and efficiency of these MW scale cold storage and food processing facilities. IcePoint generates revenue as a refrigeration asset by increasing throughput two ways. First, it provides agile cooling capacity that can scale up to four times nameplate to meet spikes in demand, allowing customers to process more product. Second, it provides dehumidification to reduce or eliminate frost within the refrigerated space which increases production be increasing coil capacity, decreasing defrost time, and maintaining higher production line uptime. Moisture control also has a significant positive impact on labor costs which is a cold chain operators largest cost center. While IcePoint does generate savings through peak rate avoidance and decreased demand charges, these features are not required to achieve industry-best economics.

Beyond IcePoint's customer focused agile freezing and dehumidification benefits, thermal storage is also inherent to IcePoint's design. The product of IcePoint is -25°F brine that is stored in a tank. With IcePoint's storage functionally subsidized by refrigeration operation, it can achieve unparalleled storage economics. IcePoint's current levelized cost of storage (LCOS) is $120/MWh, compared with $350/MWh for Li-ion batteries and $225/MWh for pumped hydro energy storage[1]. With continued development, we anticipate IcePoint's LCOS falling to $50/MWh because the storage of ice and salt (potassium acetate) is extremely cheap and if more storage capability is required - additional tank volume is all that Is required.

IcePoint is currently scalable to the full size of the large industrial low-temperature refrigeration market with eight MWh of storage per MW of power capacity. IcePoint can address smaller low-temperature refrigeration markets such as grocery stores as well.

Rebound has invented, demonstrated this technology at the industrial scale. The first commercial IcePoint unit will be installed early next year in Greeley, CO (approximately 1 hour from Rebound's HQ) after completing the factory acceptance testing currently underway.

Traditional desiccant systems consume natural gas , add heat to freezer/processing rooms, have high maintenance requirements, and are expensive. The majority of dehumidification focus for the industrial refrigeration industry is in food processing

[1] Schmidt et al., Joule 3, 81–100 January 16, 2019 a 2018 Elsevier Inc.

facilities where FDA humidity regulations that have to be met. In warehousing and distribution humidity is typically dealt with by oversizing traditional vapor compression systems because there are no food safety concerns and high moisture levels are an operational headache that is lived with until now.

IcePoint provides inherent dehumidification as an element of the refrigeration system. The working fluid is a brine that provides dehumidification through cooling and reduced water activity. IcePoint integrates with cold chain facilities through a wet scrubber. Air from the facility is cooled and dehumidified to 70% relative humidity at -30°C by direct contact with the brine. The brine is continuously reconcentrated as a core step of the refrigeration cycle and the excess water can be discarded.

By use of a freeze point suppression cycle instead of a typical liquid or solid desiccant system, IcePoint achieves moisture removal COPs up to 20X higher. This is because the freeze point suppression cycle within the IcePoint system has an ultra-efficient mechanical vapor recompression brine regeneration system build into the cycle that other liquid desiccants cannot use due to the small scale of their liquid mass flows.

The Greeley, CO demonstration will be the first time a freeze point suppression cycle will be used to dehumidify a refrigerated space.

What emerging technology advancements have the potential to meet the return on investment requirements of industrial and cold-storage facilities?

IcePoint creates the lowest cost energy storage available by integrating the storage into a system generating greater value. On the customer side, IcePoint generates value by increasing throughput via agile cooling and dehumidification and decreasing labor costs, in addition to utility savings. The embedded storage allows IcePoint to scale the cooling output to meet demand. This allows IcePoint to be sized to average demand, whereas conventional equipment needs to be sized to peak demand. Smaller equipment size with simultaneously increased productivity makes it more cost effective.

Dehumidification increases throughput in cold chain facilities by increasing the efficiency of legacy equipment. Reducing de-icing cycles and eliminating frost layers on coils increases the effective capacity.

Energy storage is provided by IcePoint via ice, but the grid only sees large capacity demand response capable of hitting long durations. Not only can IcePoint storage be used to take its own load off the grid, but it can ramp up to provide more than its own nameplate capacity allowing additional compressors to be taken offline.

Because IcePoint is so cost-effective without relying on utility savings, adding storage for demand response is the lowest cost option on the market. IcePoint's storage

manifests as ice in a fiberglass tank, both of which are inherently very low cost. The levelized cost of storage in an IcePoint system is 85% lower than lithium ion batteries.

In which utility incentive or government programs (energy efficiency and demand response) do industrial and commercial cold-storage facilities generally participate?

In our experience, cold chain operators are unlikely to participate in any electrical efficiency or utility savings programs that they perceive to threaten their core business in any way.

Because IcePoint does not have to integrate into the facilities critical infrastructure - meaning it does not tie to the central ammonia system and instead is a stand-alone system that works with air circulation - there is more flexibility for the facility to support utility requirements behind the meter.

We currently recommend utilities and governments offer IcePoint customers capital expense rebates or incentives on the purchase of IcePoint units tied to service contracts between Rebound and the IcePoint customers in which Rebound operates the IcePoint fleet as a bulk demand response asset. This benefits the cold chain operator by reducing their first costs. It benefits Rebound through increased sales. And it benefits the utility by creating a large responsive demand response asset.

Rebound is actively seeking utility and governmental partners, such as the California Energy Commission, to validate this approach. Additionally, we seek input from utilities, governments, and regulators on building out our demand response management team and tools to best address the needs of all stakeholders.

What electrical loads can be shifted in industrial and commercial cold-storage facilities? What incentives would encourage them to shift their electrical load? Do these facilities have the ability and possess the equipment to shift electrical load?

They do not today but IcePoint offers the perfect fit for the combination of customer benefit and symbiotic utility benefit in locations where IcePoint units are installed.

We agree in principle with the LBNL study cited in the RFI that the energy impact of the cold chain is so vast that even controlling a small fraction to meet demand response targets can have significant impact. However, as pointed out in the study, legacy equipment is so poorly suited to storage and retrofit storage is so expensive that this approach is not scalable to the size of the future demand response market.

With IcePoint's integrated thermal storage, the vast majority of refrigeration and dehumidification electrical loads can be shifted. We anticipate being able to scale our storage to >12 hours of storage on 90% of electrical loads in the cold chain. In the

RFI's example of 1 TWh/yr electricity consumption (equivalent to 110MW mean) by refrigerated warehouses, equivalent IcePoint systems could supply 100MW and 820 MWh of storage, vastly exceeding the 22MW capacity estimated by LBNL.

In IcePoint, the cooling capacity generation is decoupled from supplying that cooling to the facility through storage. The vast majority of electricity for generating the cooling is consumed by two sets of compressors. A low-power circulation pump and blower supply that cooling to the facility independently. Therefore, the facility cooling can continue at minimal power independently of the scheduling the significant energy consumption used for charging the cooling capacity.

What research has been conducted on increasing thermal mass (e.g., adding thermal storage) within a cold-storage facility for greater demand response participation?

IcePoint is often compared against retrofit thermal storage solutions that add thermal mass to low temperature spaces or processes because they all use ice/brine as the working fluid. In short, retrofit add-on storage solutions are failing in the marketplace. These solutions have failed to deliver the sub-3 year paybacks required by our customers. Furthermore, these increased thermal mass solutions rely heavily on existing thermal mass (IE, food) as storage. In even the most extreme cases, a rooms thermal mass can only be increased by 10-20% which means that any demand response that claims to use increased thermal mass, actually relies on changing food temperatures that risk public health.

IcePoint is fundamentally different from those technologies because the ice and brine are the refrigerants in our cycle, which vastly outperforms add-on systems in terms of efficiency without any temperature degradation. IcePoint allows conversion of nearly the entire electrical demand to a demand response participant.